MW54 Mk2&3 Turbo-Jet

Kit Assembly and Operation Manual, May-04 Edition

From

WREN

Turbines Ltd.

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Wren Turbines Ltd
5 Stoneham Street
Coggleshall
Colchester
Essex
Co6 1TT

John Roger Terry Mike

Wren Turbines Ltd is a company formed by Roger Parish, John Wright, Mike Murphy and Terry Lee.

Wren Turbines Ltd was formed initially to launch the MW54 gas turbine design and to manage the design and production of cast turbine wheels and ngv's for the engine.

This brief has now been very much widened to incorporate the production and supply of a wide range of parts and accessories for the turbine enthusiast. The company has also designed and developed turbo-shaft applications for the MW54 engine for turbo-prop and helicopter applications.

Wren Turbines have also developed a smaller engine called the MW44, an 8lbs thrust engine for the smaller aircraft. See the web site for details or call the Wren office for more information and pricing on this and other products for the jet enthusiast.

Grateful thanks to Leonie Henson for supplying the "fingers" in the assembly pic's, Sara Parish for looking after the office, sales and Wren helpline, Steve Ebbage, Charles Abson and Richard Green – the "backroom boys" at Wren and Roger, Terry and John for helping to make Wren the first choice for many in jet turbines.

Mike Murphy, June 2004.

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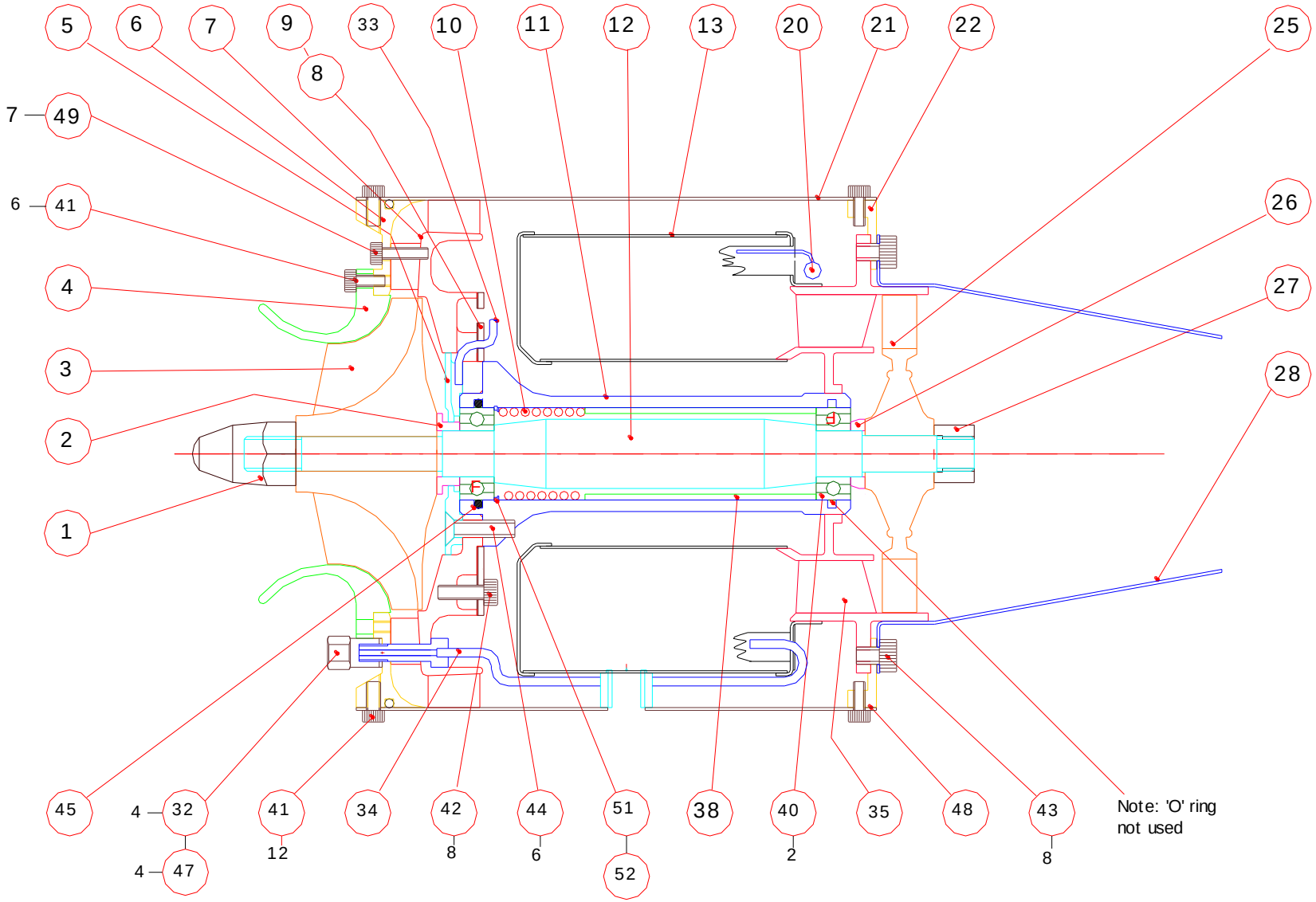
MW54 General Arrangement – refer to item numbers to aid identification – see list on page 4



Item numbers - refer to general arrangement picture on previous page for location:

1	Compressor nut	**20**	Fuel Distribution Ring	**40**	Front and Rear Bearing
2	Front Spacer	**21**	Case Outer	**41**	M2.5 x 5mm Case Front and Rear screws (12 off)
3	Compressor	**22**	Case Rear		
4	Intake Cone			**43**	M3 x 4mm NGV screws (8 off)
5	Shaft Seal	**25**	Turbine Wheel	**44**	M3 x 10mm Shaft Tunnel screws (6 off)
6	Case Front	**26**	Rear Spacer	**45**	Bearing O-ring (1 off – compressor end only)
7	Diffuser	**27**	Turbine Nut	**46**	M2.5x6 Intake Cone securing screws (6 off)
		28	Exhaust Cone	**49**	M2.5 x 8 Case Front securing screws (7 off)
10	Pre-load spring	**32**	Quick-release Service Connector		
11	Shaft Tunnel	**34**	Gas Injector Pipe	**51**	Bearing Circlip
12	Shaft	**35**	Nozzle Guide Vane (NGV)	**52**	Circlip Shim
13	Combustion Chamber assembly	**38**	Pre-load Tube		

Additional items required for completion of this kit.

We have tried hard to ensure the highest state of preparation for this kit, enabling it to be quickly built up and run. We have assumed certain basic tools are available to the constructor as would be found in a standard toolkit, to which we have added certain items we feel are appropriate and useful.

The following items are required to complete the kit:

Metric spanners – 5.5mm (Quick-release fittings), 8mm (Glowplugs), 10mm (Turbine Nut), 13mm (Compressor Nut).
Thread-locking compound – "Nutlock", "Loctite 242" or similar.
High temperature sealing compound - "Holts Gun-Gum", "Red Hermatite" high temperature silicon sealer, or similar (Mk2 engines only).

(Fuel pump, controller and other running accessories, can be ordered separately from Wren Turbines).

SAFETY NOTES

We make no apologies for positioning these notes early in the manual. Please read the following for your own safety and those around you - thank-you.

The engine must be operated only in accordance with the Gas Turbine Builders Association code of practice and the accompanying appendix – obtainable from the GTBA web site http://www.gtba.co.uk. New turbine users are recommended to read the information contained therein and to familiarise themselves with turbine operation and special precautions needed. The rotor in the engine is running at very high speed and if there were a failure of the rotor assembly it could inflict serious injury.

This engine is not a toy and can cause bodily harm to you or others if misused. Be especially on your guard toward the inquisitive spectator who may not realise the dangers of gas turbine operation. It is your responsibility as owner, to ensure safe, careful and considerate operation of your engine at all times, and in accordance with the manufacturers instructions. If you sell or give away this engine, please pass these instructions to the new owner.

All spectators should be briefed before the run on how to behave, always have a safety person with you when engine running/flying.

Always have a fire extinguisher to hand when running/flying, CO2 or BCF is ideal – dry powder, foam or water is not recommended. This engine must not be used near flammable gases, liquid or materials.

In the UK it is suggested that you join the BMFA to take advantage of their insurance cover, even if you do not wish to fly the engine.

Wear ear defenders when standing in close proximity of a running engine. This engine ***must*** only be run firmly attached to a secure and sturdy engine test stand or model installation. The thrust is considerable for such a small size and mountings must be sufficient to withstand such forces. Use appropriate screws and lock-nuts. The engine must never be run held in the hand or clamped in a vice.

During operation and for a time afterwards there are parts of the engine which are hot enough to cause serious burns – do not touch any part of the engine until it has cooled to room temperature. This engine generates large quantities of heat – ensure the mountings and installation are appropriate for operation at these elevated temperatures. The exhaust gases are very hot (over 450'C) on leaving the engine and can cause burns to skin or damage to objects close to it – keep exhausts clear of anything which is affected by such heat.

Always operate your engine in open air away from confined spaces as the engine exhaust contains gases which can cause asphyxiation and nuisance from smells.

Turbine fuel is poisonous to living beings. Keep away from mouth and eyes and contact with skin. Always store in a marked container out of reach to children.

Turbine fuel has a relatively high flash-point but in certain circumstances can be highly flammable. Keep it away from heat and sources of combustion.

The starting gas is highly flammable and must be used with extreme care. Maintain canister and fittings in good leak-proof condition. Protect from sunlight and prevent exposure to temperatures exceeding 50'C. Keep out of reach of children. Discard used canisters in a safe place and do not puncture or incinerate, even when empty. Avoid deliberate inhalation.

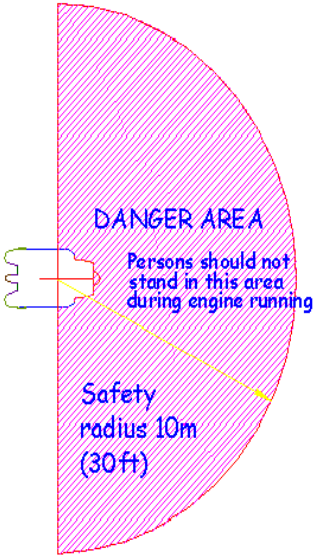
Ensure gas only is supplied the engine, liquid gas must not be allowed to pass into the system. Gas supply must be disconnected until ready for immediate use. Gas is heavier than air and can fill a model if allowed to leak unchecked, and become a potential explosion hazard.

Turbine oil can be are hazardous to health and must not be allowed to come into contact with skin, mouth, eyes or through ingestion, accidental or otherwise. Take care when decanting and ensure any spillage is wiped away immediately and clean any affected area with warm soapy water.. Wash hands and any affected part immediately after any contact. Turbine oil can discolour or affect certain paint finishes as may be used. Take precautions to prevent spillage . Do not discard or allow any spillage to run into drains.

If checking glow-plug operation, keep fingers or bare skin away from possible burn from the glowing element – use a metal tool or appropriate insulation.

As operator, it is your responsibility to ensure any spectators (especially small children) or helpers are kept well away from the engine whilst it is operating. The safest position to operate the engine is directly in front. The area inline and to the rear of the turbine is the most dangerous area and you must keep well clear of this.

Keep all spectators away from the side and rear of the engine to a distance of at least 10mtrs (30ft) radius, as shown. If operating from a pit area take special care as safety distances are often difficult to maintain.



Keep all helpers close by and brief them fully on their duties before starting the engine. One helper should carry out the role of fireman. Ensure they are aware of what to do in event of emergency and where to position the extinguisher if required.

Do not attempt to alter the starting characteristics of the engine by spraying ignition agents into the intake, as might be used for gasoline and diesel engines. A dangerous fire and flashback may result.

Finally please note, the exhaust of a gas turbine has a pleasing smell to enthusiasts of gas turbines but others may find it offensive. Please have consideration for others when running your engine in their proximity.

Wren Turbines welcome feedback on this or other of their products, email on wren@parish.f9.co.uk or write to:
Wren Turbines Ltd, Unit 13, Century Business Centre, Manvers Way, Manvers, Rotherham, S63 5DA, England
Tel +44 (0) 1709 300290, Fax +(0) 1709 300291

The MW54 Mk2 and Mk3 Gas Turbine Kit - Introduction.

This kit is a development of our very popular MW54 Mk1 kit introduced in Dec 2001, of which over 200 have been sold. This earlier version required some metalworking to complete and customer feedback had indicated it would benefit from a more complete level of fabrication. The Mk2 version was in response to this and as a result there is no metalworking or soldering/brazing required for it's completion. The Mk3 version is exactly the same engine but includes a deluxe one piece machined stainless case and exhaust nozzle and the turbine comes pre-balanced on the shaft for convenience. The extras are available to Mk2 owners for upgrade at any time to suit their budget and timescale.

The concept of the kit gas turbine engine is to bring to the modeller the latest in miniature turbo-jet technology but at an affordable price, and in the process help the modeller to gain familiarity with this new breed of internal combustion engine. The kit is for the thrust engine in its simple but fully functional form, to which the builder can add their choice of accessories such as a stylish anodized green front cover, pod-style on-board starter and clutch system, single-piece stainless case, tuned twin piece exhaust, thrust tube, FOD screen etc, all available from Wren Turbines. This approach allows the builder to stage their construction to suit their time-scale and budget and chosen application. Additionally, the engine can be fitted with alternative versions of the popular FADEC ECU such as the Manual ECO or Auto-start version, (for which the green cover and pod starter are required). To this can be added a simple external gas start system or a full on-board gas start system and as these are all standard accessories for the Wren range of MW54 engine turbines, you can be sure of plenty of choices when building up your turbine installation.

Builders who have purchased the MW54 plan-set (available from Wren Turbines) which covered the in-depth construction from an engineering viewpoint, will note several changes have been made to facilitate ease of assembly over the original design, although the basic design remains the same. It is not intended to change the plan for the foreseeable future. The extras listed above and the balancing options following also apply to the "homebuilt" version of the engine. All components of the engine are available separately as spares enabling you to structure your project to suit your chosen timescale and budget.

Balancing.

We are regularly asked about balancing and we have accumulated a lot of experience as to what is acceptable and what is not, and what forms of in-balance correction are realistic. To achieve satisfactory smooth running of our engine we need a good standard of dynamic balance and how this is achieved is the focus of this section. We have tried to keep the description of this complex process as straight-forward as possible and we apologize in advance if the reader finds the section overly simplistic.

The two main forms of balance we are concerned with are *static* and *dynamic*. The simple way to appreciate the difference is to turn a bicycle over, remove the chain and observe the pedals remain somewhat at rest, ie in *static* balance. However if we spin the pedals quickly the bicycle will wriggle about from side to side, ie not in *dynamic* balance. On our engine the two components which are individually out of balance are fairly narrow discs so we can easily distribute the out-of-balance correction without generating what is called a *couple* – effectively a wobble. The shaft can be regarded as not requiring balancing as it is highly precision ground and concentricity run-out is unlikely or of small consequence here.

To achieve a pseudo dynamic balance of our engine we do the equivalent of balancing just one pedal without the other attached, ie we first balance the turbine mounted on the shaft (with its bearing, spacer and nut) and then replace the other *pedal*, ie the compressor, and balance this to achieve an overall balanced rotor. The turbine has considerable mass and will always require correction before use due to the casting process. It is supplied ready mounted to the shaft and should not be removed except to replace the turbine bearing. Being narrow, it can be successfully "dynamically" balanced as it is quite easy to show

the point of in-balance and minimize it using simple procedures as outlined in our "Balancing Instructions" leaflet. By sharing out the correction to each side of the turbine we achieve a reasonable dynamic balance condition.

The compressor is supplied pre-balanced and the only source of in-balance here is due to the fit of the compressor to the shaft. In order that it is able to slide onto the shaft it must be bored fractionally larger than the shaft and this looseness is where a potential in-balance at the compressor end occurs. The state of *dynamic* balance can be checked for by spinning the rotor assembly (whilst assembled into the engine) to around 15,000rpm and feeling for vibration through the case as it runs down. Although no figures can be attached to this test it is possible to get a good measure of the state of in-balance. Often, just loosening the compressor nut and turning the compressor slightly results in a significantly improved balance condition. Conversely, simply loosening the compressor nut on a previously balanced engine can often throw it out of balance. If an engine is run in a poor state of balance it can ruin both bearings in a matter of minutes.

As balancing is a labour intensive process (and therefore expensive) we have made it possible for you to save money by doing some of the balancing yourself.
To help you choose and to limit the confusion we offer three options in ascending order of cost and descending order of effort for you:

1) You balance the engine at home during assembly, (takes about 3 hours average for good results), no need to return the engine.
2) We balance the turbine wheel on the shaft, at the factory before dispatch of your kit, no need to return the engine, (standard on Mk3 engines).
3) Engine is fully dynamic balanced on compressor and turbine. Engine requires return to factory after test running.

To help you with option 1 we include step-by-step instructions for achieving a good standard of balance sufficient for normal running of the engine that can be performed at home. This procedure has enabled countless other builders to build and run good engines which run smoothly and quietly. All that is required is a short length of tube and a hand-held grinder such as the "Dremel" and a 30mm (1-1/4") grinding disc.

With option 2, for which there is an additional charge for Mk2 kit builders, the turbine is factory balanced on the shaft to a high degree (below 50mg/mm at balance ring). Due to the need to have the compressor a sliding fit on the shaft there is likely to be a small degree of residual in-balance but in most cases this is minor. In all cases, balancing will require removal of a small amount of material from the balance rings on the turbine and the front face of the compressor.

With option 3, to which there is an additional charge, you get the best guarantee of perfect balance although is the most inconvenient from the users point of view as it requires return of the engine to the factory, postage and packaging etc. This option of factory balancing on the complete engine (*full dynamic balance*) is performed with the engine in assembled and tested form on a special balancing assembly called a *dynamic table*. This results in the rotor assembly exhibiting lower than 50mg/mm in-balance on compressor and turbine. Before return for dynamic balancing, the engine should be run at least a couple of times at moderate speeds to allow components to settle and stresses to be relieved and to ensure correct operation. **Note;** if subsequent running shows a problem you may need to strip the engine for investigation and this will affect quality of balance, so you should ensure satisfactory operation before sending the engine for dynamic balancing. Marking the position of the compressor to the nut may be only partially successful at retaining rotor balance on strip-down.

To review - the quality of balance will be affected if the rotor is disturbed – loosening the compressor nut is sufficient to alter the balance condition. Therefore do not take apart unless the engine has a mechanical problem or you are replacing the bearings due to normal wear.

Please note that the balancing operation is just that, Wren Turbines cannot perform test running or fault finding on an engine as part of the balancing operation. Additionally, if bearings have been damaged through excessive running in an out of balance condition then we (Wren Turbines) may be unable to

balance the rotor satisfactorily due to bearing noise. Repair work for bearing replacement and subsequent balancing is charged at our standard rate as shown on our price listing.

Spares and servicing.

By purchasing a high cost product like a gas turbine in kit form you are able to make a considerable cost saving over a ready-built and tested version, which reflects the labour expended and warranty issues. Assembling the engine yourself also equips you to tackle servicing or rectification due to crash damage or similar incident. To help, spare parts for servicing or repairs on your engine such as bearings, exhaust components, pipe-work, cases etc are all readily available at modest cost and mostly ex-stock, from Wren Turbines. Please note that this saving also recognises that servicing and any fault finding required for your engine is your responsibility although Wren Turbines can offer verbal assistance where practicable. It is not possible for Wren staff to perform fault-finding and/or test running of a kit engine unless agreed in advance, where a charge will be made. Please note that if you decide to incorporate your own modifications or "improvements" to your engine Wren Turbines cannot assume responsibly if it fails to perform as expected or develops faults that may be attributed to such changes. Wren Turbines cannot accept responsibility for damage or incorrect operation where it is found that non-genuine Wren Turbines parts have been fitted.

Set-up for testing.

Once you have built up your engine we strongly advise that you do not install it straight into a plane or similar installation without bench testing and confirming the start sequence and normal mode of operation. For such testing it is useful to assemble the parts you intend to use in your installation, tank, filter system, pump, ECU etc and connect them all up on the bench.

The engine can be mounted using a suitable mounting system such as the Wren two part mount and secured firmly into place. All pipe work must be suitable for kerosene and we recommend "Tygon" type soft tubing for tank feed to pump and 3mm "Festo" type fittings for the pressure side of the pump to the engine. We suggest you use a good quality felt filter clunk for your pick-up in the tank. Use 4mm pipe work (solid or flexible) to feed from the tank to your fuel pump. Do not use any other filters or valves in the *input* side of the pump as we have found they are the major cause of engine problems with air ingress. It is advised you fit an in-line pressure filter in the line just before the engine as a "*last chance*" filter. If a fuel shut-off valve is required then install this in the pressure side of the pump. A version is available from Wren.

Fuel for the engine is clean and filtered Kerosene or Jet A, with a 2.5% (40:1) mix of non-synthetic outboard motor oil to TCW3 spec', or standard turbine oil such as Exxon 2380, Aeroshell 500, Mobil JetOil or similar. Starter gas should be propane/butane gas only mix (no dip or slop tube), supplied through an adjustable control valve and pipe-work able to handle 2Bar (30psi). If you wish to read pressure, then use a "Tee" off the gas line and a gauge reading 2Bar (30psi) minimum, and pipe-work to match. Please ensure the engine intake is kept well clear of any loose objects. Glow-plug leads, pipe-work, rags, sleeve cuffs and unfortunately - fingers have all been known to be "hoovered" into the engine so please be especially careful. See the sections at the back of this instruction booklet for running instructions – ***and take care!***

Layout of instructions.

The order of assembly for this Mk2 kit as shown in the following pages, is the suggested sequence to follow and has been tested for logical flow and ease of understanding, we would be pleased to receive your comments on this!

IMPORTANT – do the balancing of the rotor FIRST if you have taken this option, as you need to use the bearings. After this the bearings are not accessible.

MW54 Mk2 Gas Turbine Specifications (no accessories).

Length 136mm o/a (bare engine), 179mm o/a inc' exhaust cone.
Diameter 89mm
Weight 780gms (1Lb 11-1/2oz)*
Pressure ratio 2.65
Mass flow 0.18kg/sec (23-3/4Lbs/min)

Thrust – 55-60N, 12-13Lbs (Mk2) 62-67N, 13.5-15lbs (Mk3)*
Max rpm - 160,000
Idle rpm – 40,000
Self sustain rpm - 28,000 *
Max case pressure - 1.65 Bar (24.5psi)*
Idle case pressure - 0.07 Bar (1psi)*

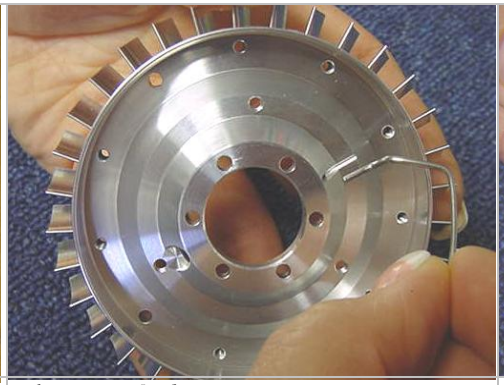
Fuel consumption:*
200ml/min (Mk2) 210ml/min (Mk3) approx @ max thrust
50ml/min @ idle thrust
Fuel - Kerosene or Jet A1 with 2.5% oil (40:1 mix)
Fuel pressure @ max thrust – 2.6 Bar (38psi)
Fuel required for average 6-min flight – 1200ml (40oz)

Oil mix required - 25ml per 1Ltr fuel, (1oz per 40oz fuel)
Oil - Turbine oil such as "Exxon 2380", "Aeroshell 500 or 510", "Mobil JetOil".
Alternative - TCW3 specification, non-synthetic, outboard motor oil
Average aircraft flying weight – 3 - 9kg (7 – 20Lbs)

* = Typical engine.

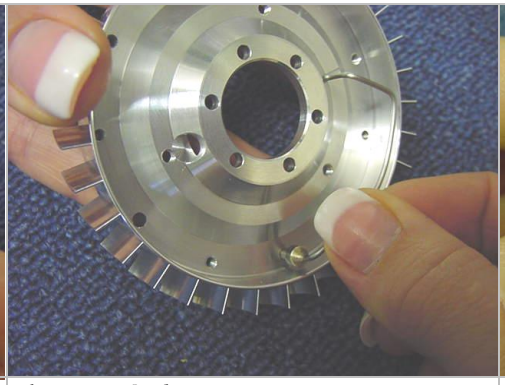
Building the engine – start here :

Step 1. Parts set.
Familiarise yourself with engine parts, read all steps carefully before starting. Proceed **directly** to balancing booklet if yours is an unbalanced



Step 2. Lubrication pipe.

Insert pre-formed lubrication pipe through the 1.5mm slot.

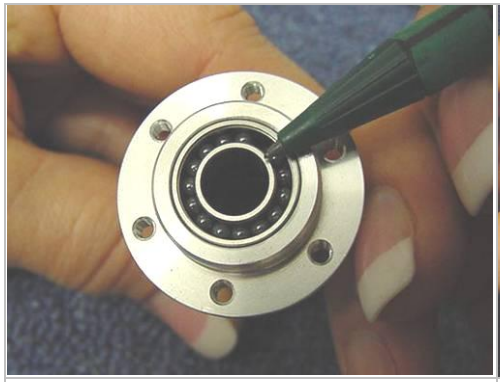


Step 3. Lubrication pipe.

Insert lube' pipe connection into correct hole in Diffuser, and position feed end at cut-out.

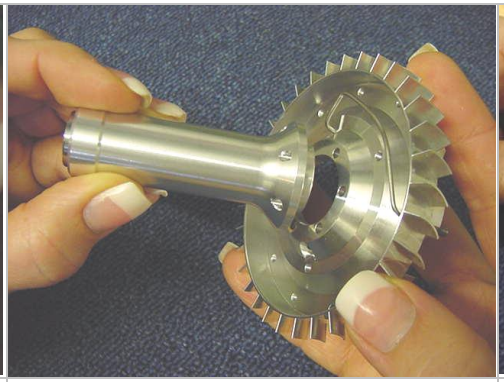
Step 4. Shaft Tunnel.

Insert front bearing this way round (printed arrow points out).



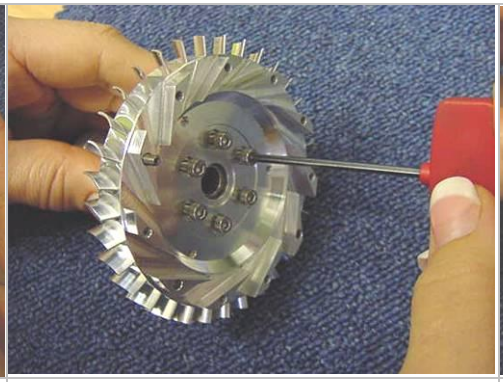
Step 5. Shaft Tunnel.

Check thick side of inner ring faces out (other side is thin).

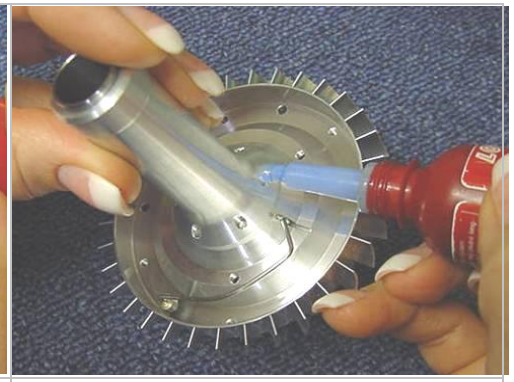


Step 6 Shaft Tunnel.

Fit Shaft Tunnel into rear of Diffuser and align fixing holes. Note Tunnel is supplied as a complete assembly.

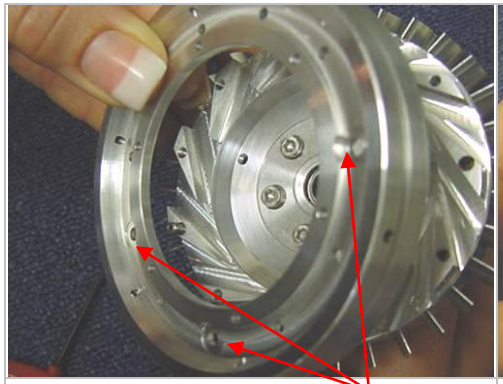


Step 7. Shaft Seal/Shaft Tunnel.
Align Shaft Seal with groove over lube' pipe and place into position. Secure loosely with six M3 x 10 cap screws.



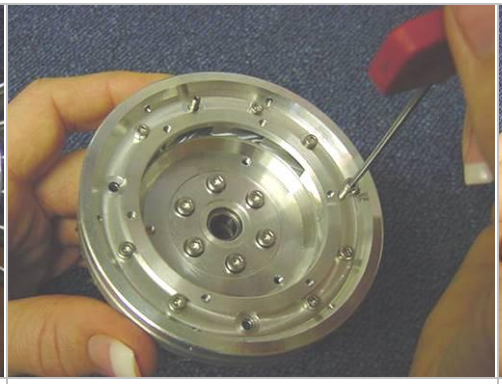
Step 8. Shaft Seal/Tunnel.

Loosen each screw in turn by 3 turns, apply drop of locking compound, and tighten firmly and evenly.



Step 9. Case Front.

Align Case Front over Diffuser – use the three large holes to position.



Step 10. Case Front.

Secure with 7 M2.5 x 8mm screws, but do not tighten up as yet, as we need to centre the Case Front later.

Step 11. Aligning Case Front.

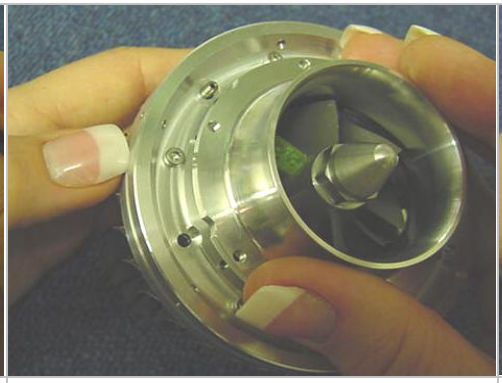
Insert (balanced) Shaft assembly into Shaft Tunnel – be extra careful when easing through front bearing.

Step 12. Aligning Case Front.

Holding the shaft in against the pre-load spring, insert the front spacer – small diameter downwards. Do not press hard as you might "pop" the bearing apart.

Step 13. Aligning Case Front.

Slide on Compressor and secure with Compressor Nut – note it has a left-hand thread.



Step 14. . Aligning Case Front.

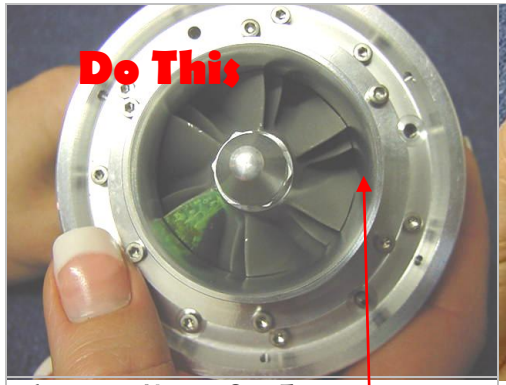
Fit the Intake Cone onto Case Front, be careful to align the service cut-outs correctly.

Step 15. Aligning Case Front.

Secure Intake Cone with the M2.5 x 6mm screws, temporarily.

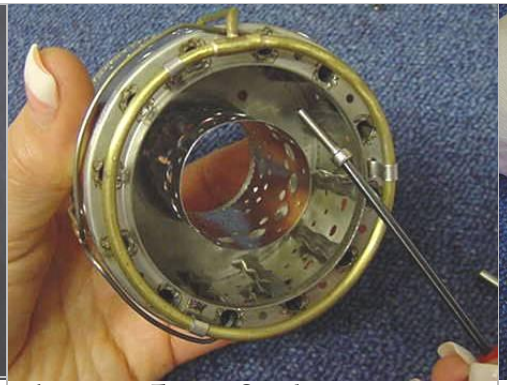
Step 16. Aligning Case Front.

Place NGV with turbine shroud up, and gently lower assembly into it – turbine will rest on rim, not the blades.



Step 17. Aligning Case Front.

Spin Shaft Tunnel and view gap between Compressor and Intake – adjust by easing Case Front across until it is perfectly even, & tighten the eight M2.5x8 fixing screws. Check, then remove Intake Cone, Nut, Compressor, & Spacer, and set aside.



Step 18. Fitting Combustion Chamber.

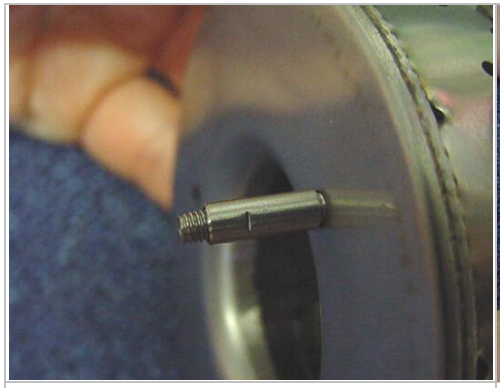
Chamber is supplied with fuel and gas manifolds ready fitted.
Insert one of the 3 off M3x14mm cap screws through the chamber front, from

Step 19. Fitting Chamber stand-offs.

Slip one of the short metal tubes onto the screw, holding the screw in place with the hex key.

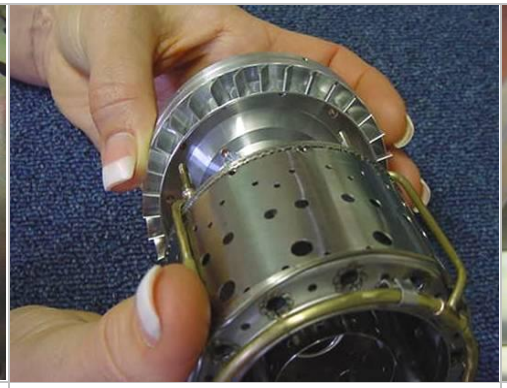
Step 20. Fitting Chamber stand-offs.

Using a pair of side cutter pliers, crimp the tube onto the screw to retain it.



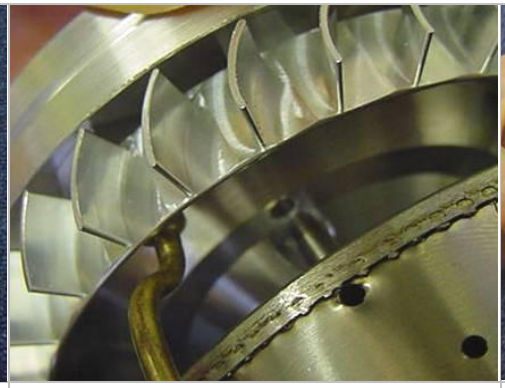
Step 21. Fitting Chamber stand-offs.

Crimped tube shown here. Repeat for remaining two tubes.



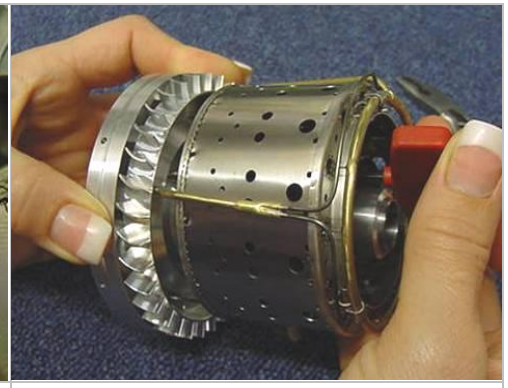
Step 22. Fitting Combustion Chamber.

Align and insert fuel and gas fittings to the holes in rear of diffuser.



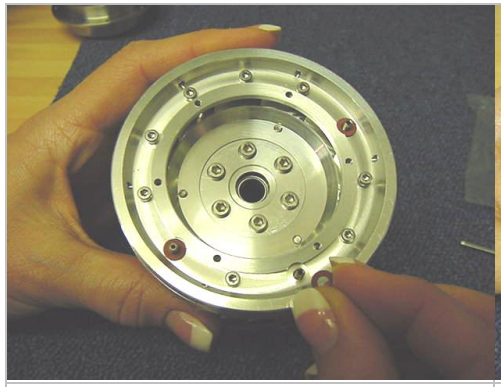
Step 23. Fitting Combustion Chamber.

Align the 3 stand-offs to the mounting holes (bend fuel/gas pipes if needed).



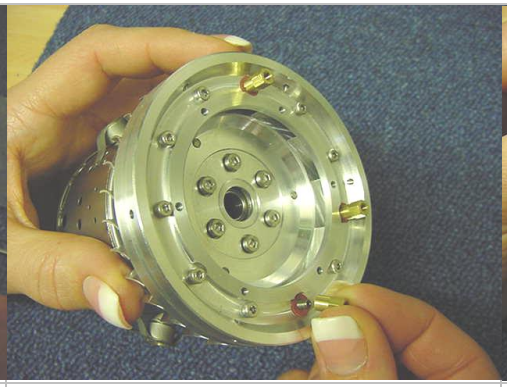
Step 24. Fitting Combustion Chamber.

Screw in and tighten the three stand-off screws, ensuring the fuel/gas fittings are pressed fully home.



Step 25. Connecting services.

Fit fibre washers to each of the three service fittings.

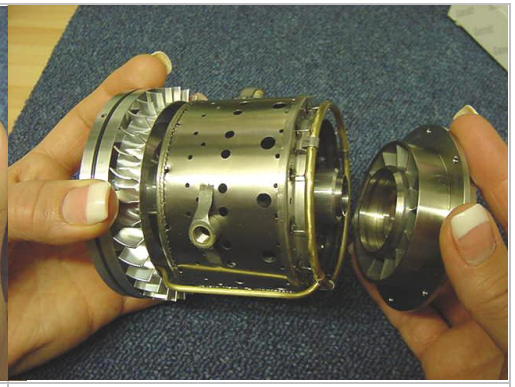


Step 26. Connecting services.

Screw on the three brass service adapters and tighten gently. Do not fit the push-on fittings yet.

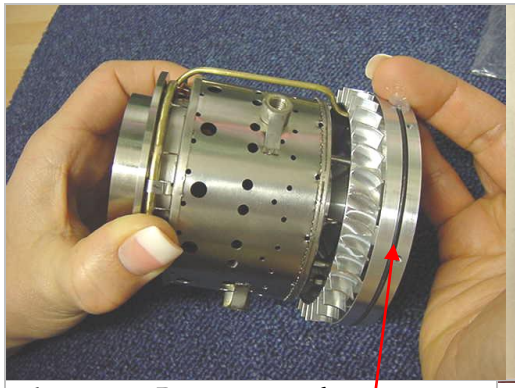
Step 27. Sealing ring.

Fit the O-ring to the Front Cover, be careful not to damage the section on the sharp groove edges.



Step 28. Fitting Nozzle Guide Vane.

The NGV can now be eased onto the end of the Shaft Tunnel and Combustion Chamber.

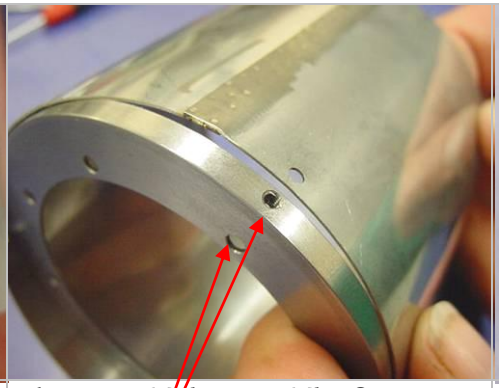


Step 29. Preparing to fit case.

Apply a small smear of silicon grease or petroleum jelly to the O-ring to help it slide into the Outer Case.

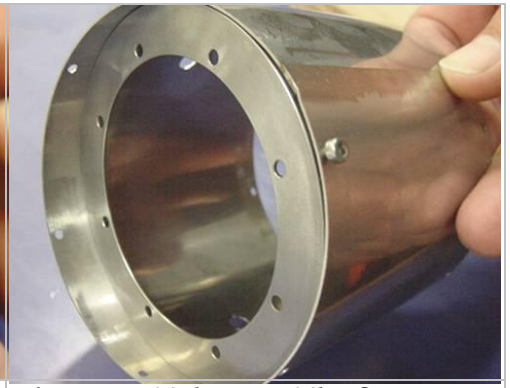
Step 30. Making up Mk2 Outer Case.

Find the "WREN" mark on the case – this indicates *front-end, top*. Now rotate it 180' and locate the hole at the *bottom* of the *rear-end* (the hole



Step 31. Making up Mk2 Case.

Insert the Case Rear at a slight inward angle. Align at the point where case and NGV holes come together.

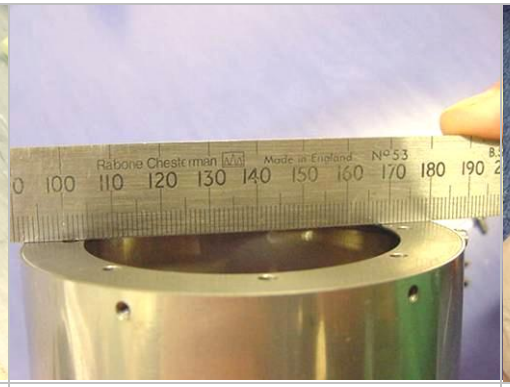


Step 32. Making up Mk2 Case.

Screw in about four turns, one M2.5 x 5mm screw into this hole to act as a peg (locate in centre, as hole is oval).

Step 33. Assembling Mk2 case

Rest assembly on flat surface and using a block of wood or metal drift, tap Case Rear into place, level with end of case.

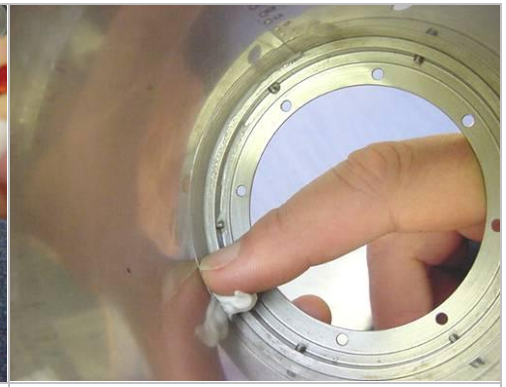


Step 34. Assembling Mk2 case.

Check the Case Rear is exactly flush with the end of the case, using a metal rule or straight edge.

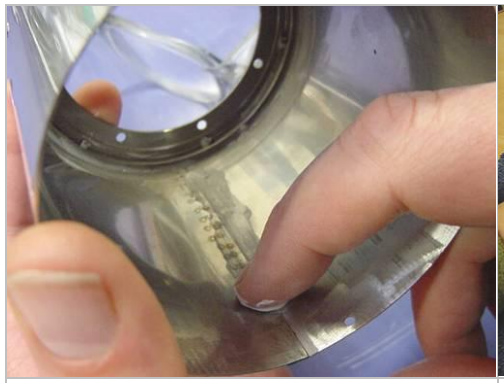
Step 35. Assembling Mk2 case.

Fit the remaining 5 screws, thread-locking them all into place by loosening each in turn, as before.



Step 36. Sealing Mk2 Case Rear.

Seal in place with a small fillet of high temperature sealing compound (Holts "Firegum" shown here).



Step 37. Sealing Mk2 case seam.

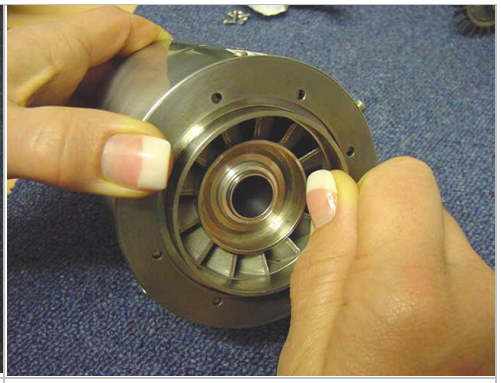
Finally, finish off with a light smear along the welded seam inside the case.

Step 38. Fitting Mk2 case.

Align the two glowplug holes with those on the Combustion Chamber and gently slide case on.

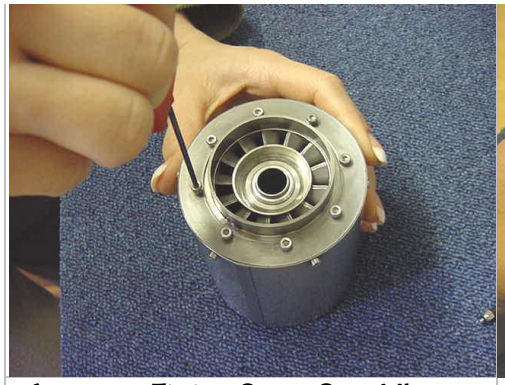
Step 39. Fitting Outer Case.

Holding the engine as above, gently ease the case into position, being carefully not to nip fingers or O-ring.



Step 40. Fitting Outer Case.

Gently pull the NGV outwards and press/turn it to align with the eight screw holes.

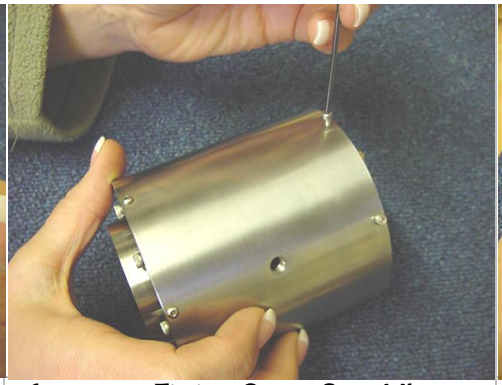


Step 41. Fitting Outer Case Mk2.

After aligning the NGV, fit the eight M3x4 screws and tighten evenly.

Step 42. Fitting Outer Case Mk2.

Confirm the glow plug holes are correctly positioned. Make small adjustments as required.

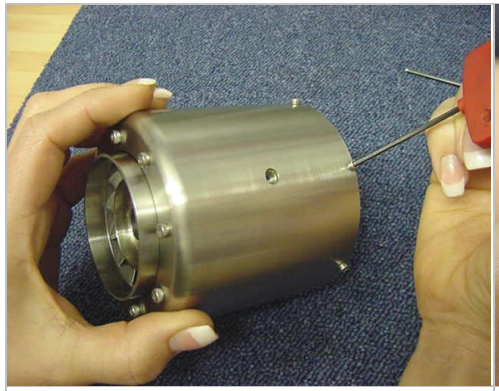


Step 43. Fitting Outer Case Mk2.

The six M2.5 x 5 screws can now be fitted to secure the front of the case.

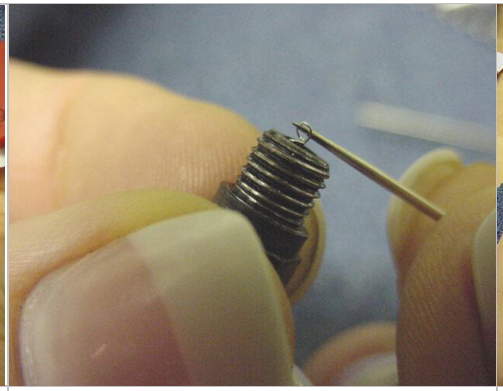
Step 44. Fitting Outer Case – Mk3.

The Mk3 case is installed in the same way, after carefully pressing on, pull NGV into position and secure with eight M3 x 4 screws, as before.



Step 45. Fitting Outer Case Mk3.

Fit the six Outer Case securing screws once NGV has been secured.

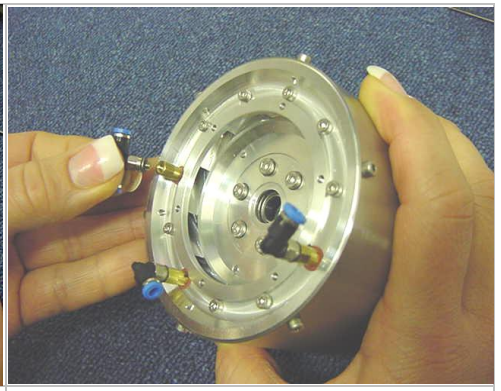


Step 46. Preparing the glow element.

Prepare the glow plug by carefully teasing out plug element with a pin. Make the bend gently to not break the fine wire

Step 47. Fitting Glow Plug.

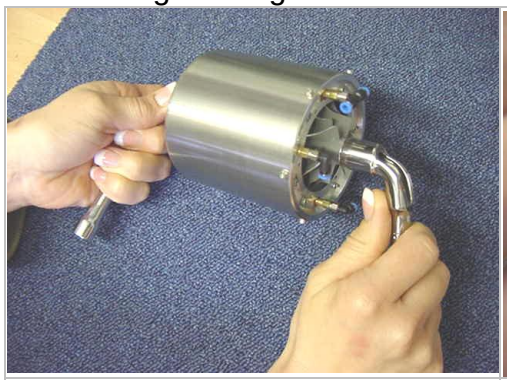
Fit the glow plug(s) and tighten firmly. The copper washer is **not** required and can be left out.



Step 48. Fitting Service Connections.

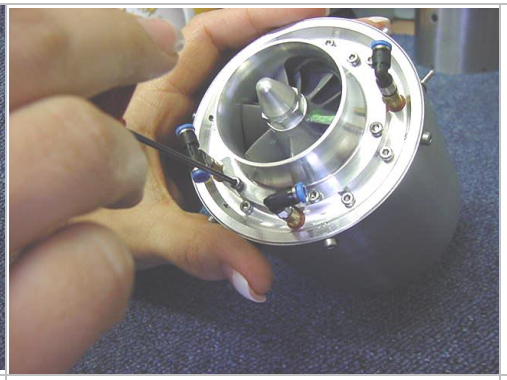
The main assembly is complete, we can fit the quick release fittings and tighten gently – note placing.

Assembling the engine.



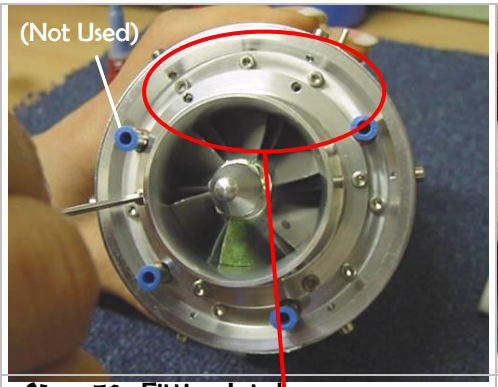
Step 49. Re-fitting rotor assembly.

Carefully insert the turbine rotor into the casing and fit Front Spacer, Compressor and Compressor Nut and tighten firmly. Torque setting for Compressor Nut is 6Nm or 54lb/ins if torque wrench available.



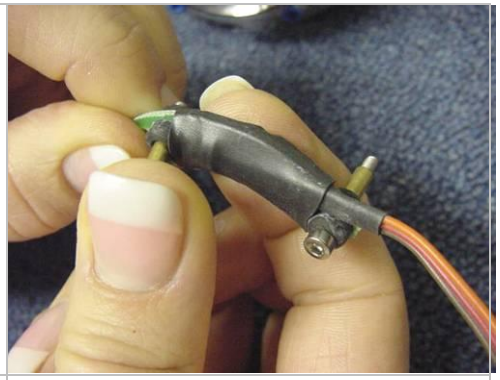
Step 50. Fitting Intake.

Position Intake over compressor and align cut-outs for service connectors. Secure with four M2.5 x 6 screws (see next step) – use locking fluid to retain.



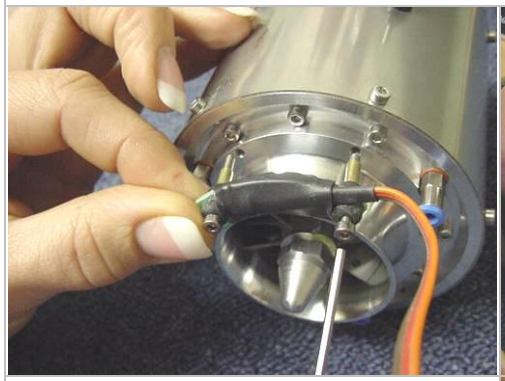
Step 51. Fitting Intake.

Leave the top two fixing holes vacant – this is to allow fitting of the RPM pickup. *Pic' shows earlier style of connectors.*



Step 52. Prepping the RPM sensor.

Press the brass tube spaces into the rubber grommets on the sensor. Wire should protrude at r/h side.

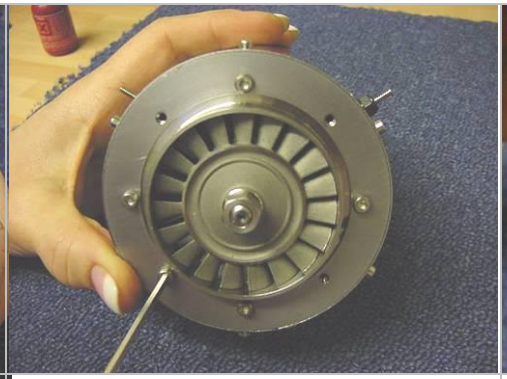


Step 53. Fitting RPM sensor.

Fit the RPM sensor to the two vacant holes above the Inlet using the two M2.5 x 20mm cap screws.

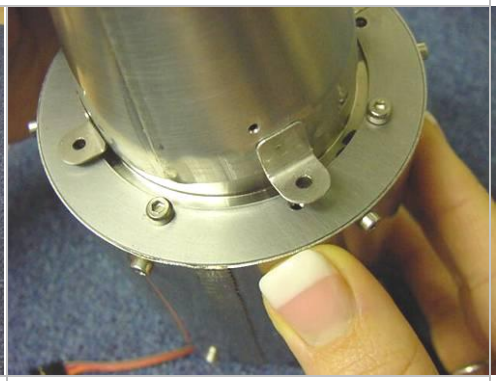
Step 54. Fitting lube' feed pipe.

The Lube' feed pipe is connected between the tee and angle fittings, above the Intake. Ensure pipe is pushed fully home to seal properly.



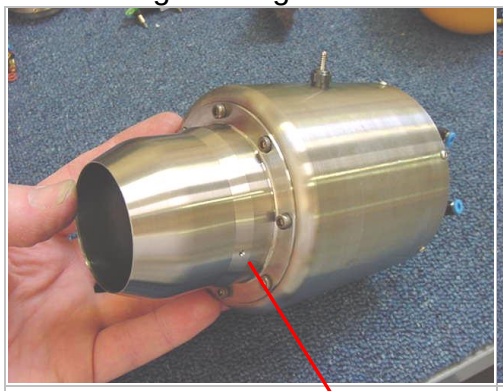
Step 55. Fitting Exhaust Cone, Mk2 & 3.

Remove four of the M3 x 4 NGV fixing screws, as shown above.



Step 56. Fitting Exhaust Cone (Mk2).

Fit the Exhaust Cone, positioning the temp' probe hole at 4 O'clock. Refit the four M3 x 4mm screws.



Step 57. Fitting Exhaust Cone (Mk3).

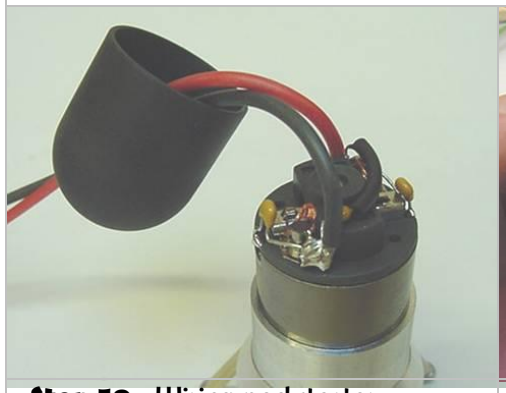
Fit the Exhaust Cone, positioning the temp' probe hole in the 4 O'clock position. Refit the four M3 x 4mm screws.

The Mk3 engine complete ready for mounting and test running. Additional accessories can also be fitted -

Pod style on-board starter and cowl for the MW54. Suits direct switching (7.2V) or Autostart ECU operation. Motor is 280BB with Wren miniature clutch.

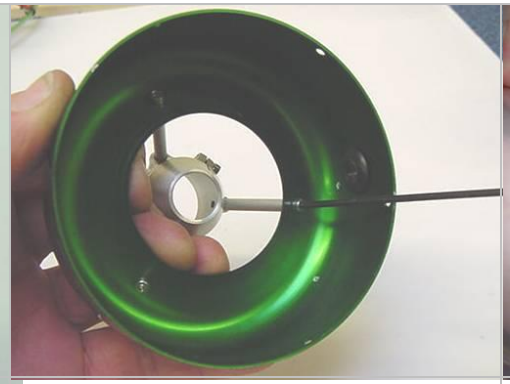
Step 58. Assembling pod starter.

Solder suppressor capacitors to the motor brush terminals – one each 47nF from brush to case and one 100nF brush to brush.



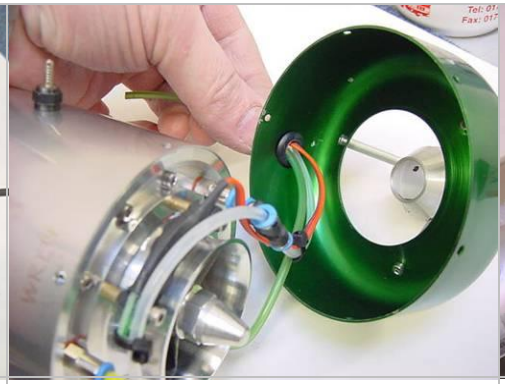
Step 59. Wiring pod starter.

Thread starter wire through cap and solder to terminals – check polarity is correct using battery.



Step 60. Fit starter pod to cowl.

Align pod legs to cowl and insert 3 off M2.5 x 5 screws, using locking fluid to secure.

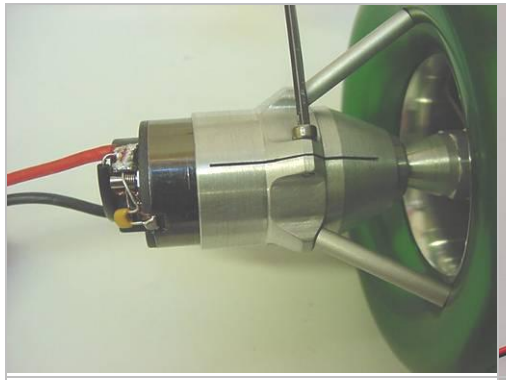
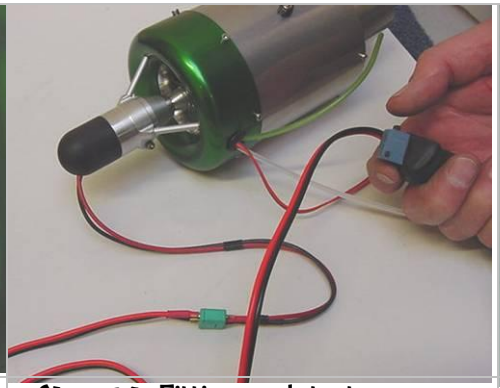


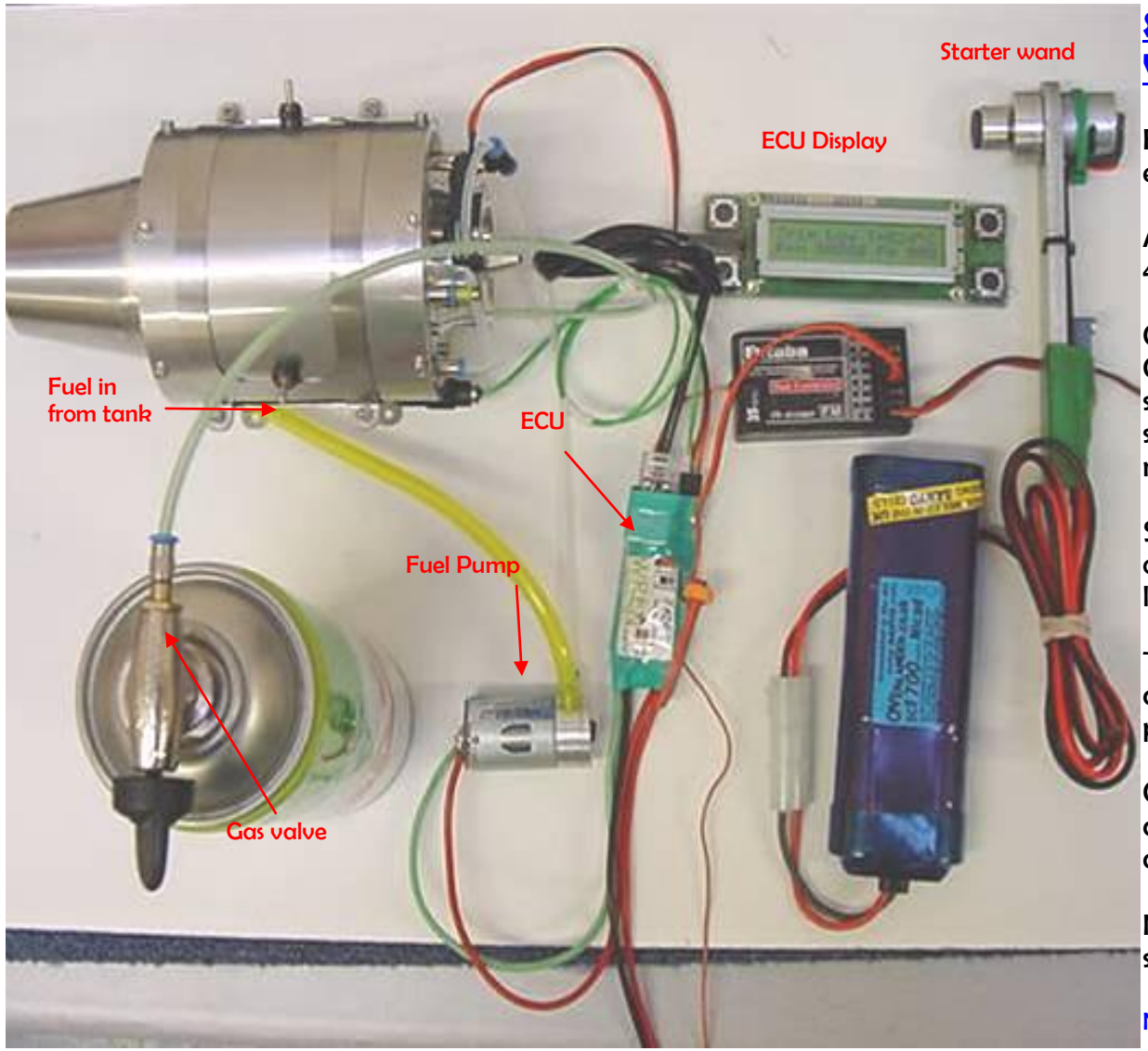
Step 61. Fitting cowling.

Fit grommet to hole and thread rpm sensor cable, fuel and gas pipes (and pressure pipe if fitted).

Step 62. Fitting cowling.

Remove the six Case fixing screws and ease cowl into place. Refit the fixing screws and tighten.

			
Step 63. Fitting pod starter. Slide motor into place fully and pull back approx 1mm. Nip into place by tightening M2.5 cap screw.	**Step 64.** Fitting pod starter. Check operation be connecting switch start lead and battery. Action should be clean and "snappy". Ease pod position if clutch sticks at all.	**Step 65.** Completing pod starter. Once correct operation is confirmed, the black cap can be eased into place.	A filter screen cover can also be fitted to engine. Provides mounting for on-board starter. Suits direct switching (7.2V) or Autostart ECU. Pipes exit at bottom. Fit as for pod starter.
Not Used	Not Used	Not Used	Not Used



Set-up for bench-test running
With Fadec ECO ECU and hand starter.

For engine bench-testing secure the engine to an engine mount* screwed to a firm base.

Attach thermocouple probe to engine and insert end 4mm into exhaust. Secure body with clip provided.

Connect thermocouple and rpm sensor to the ECU. Connect fuel pump and ecu battery (4-cells) and the starter gas supply via a quick-acting valve* to the gas supply port on the engine. Connect ECU signal lead to receiver and set-up radio as described in next section.

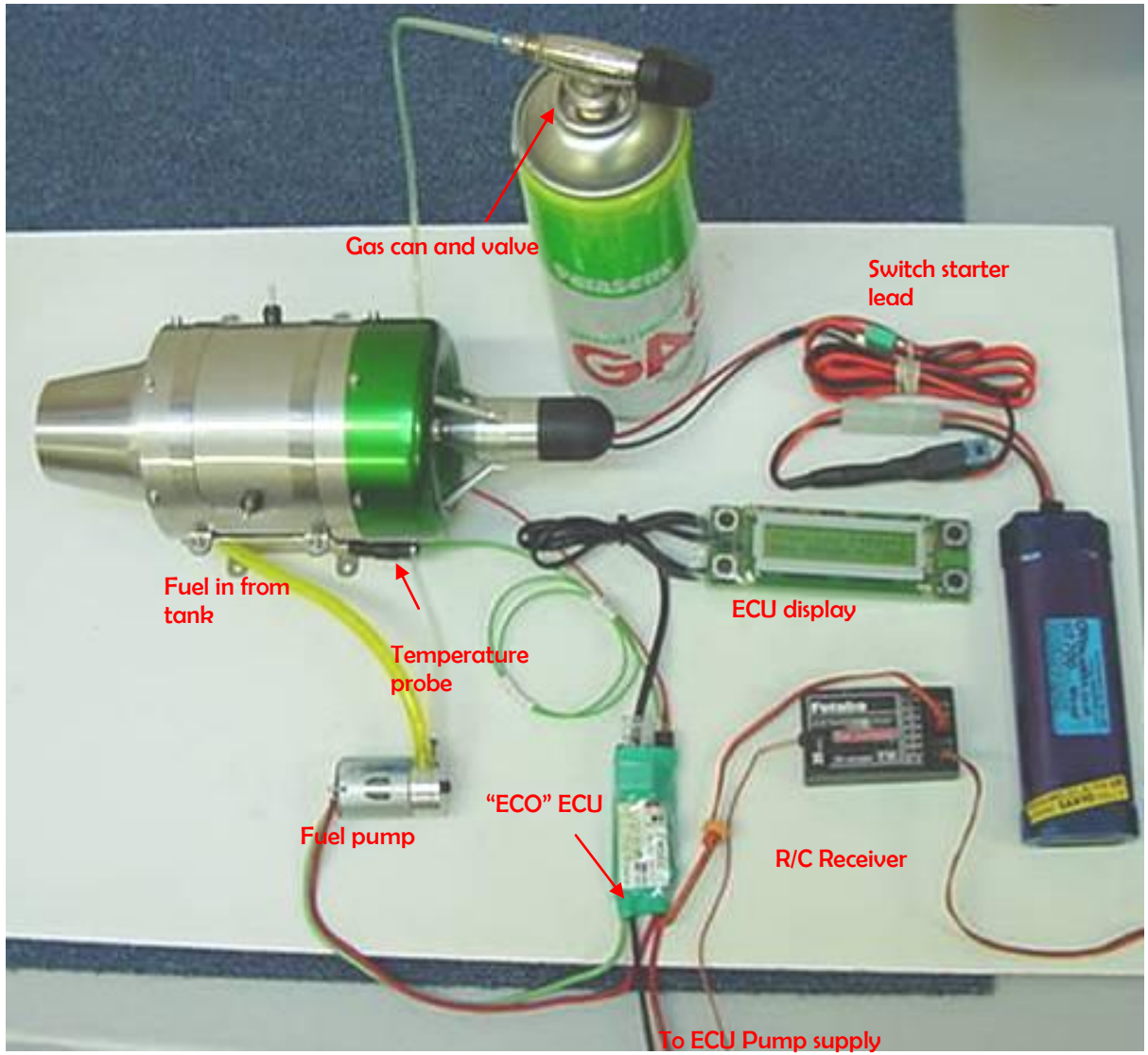
Secure fuel tank and connect to fuel pump. A fuel on/off valve may be connected in the fuel pressure line.

The ECU readout should also be secured – sticky pads are suitable for quick testing. Once secured it can be plugged in and you are ready.

Connect a 6-cell charged nicad to the hand starter and spin the engine and check the rpm reads on the display.

Note, picture shows Mk2 version, Mk3 version uses same setup and range of accessories.

NB. * Indicates accessories available from Wren Turbines Ltd.



Set-up for bench-test running
With Fadec ECO ECU and switch starter.

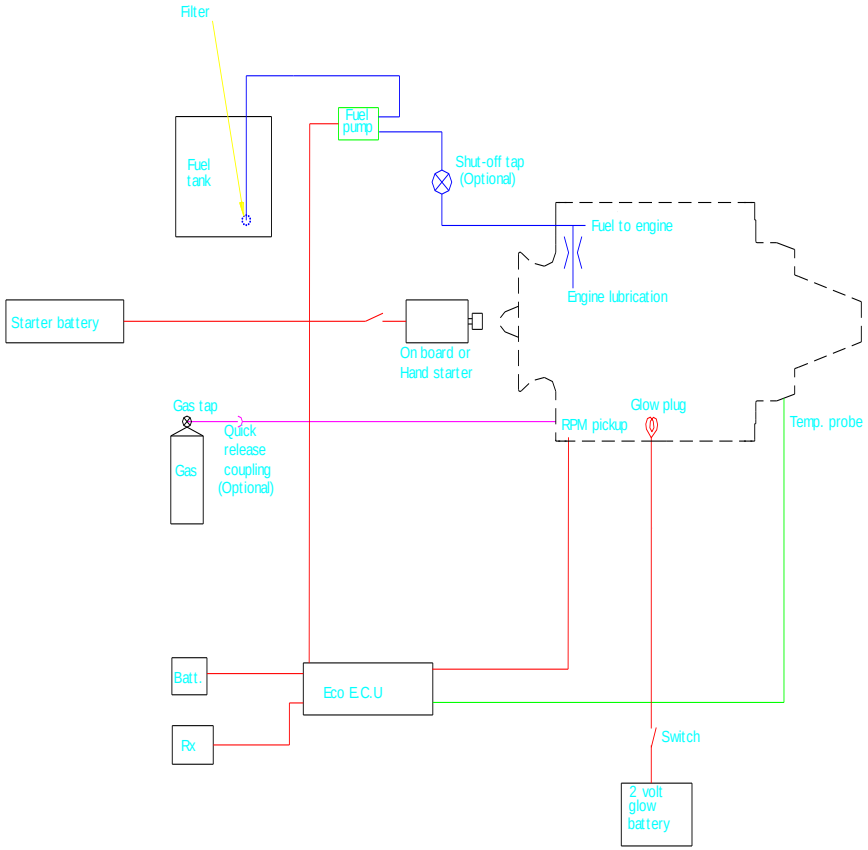
Set up is the same as for manual ECO except that the green cover* and starter pod* are fitted to the engine. Connect a "switch-start"* lead to the starter and a 6-cell nicad* to the lead. The starter is then controlled by the switch. Note the switch must short the motor on release of the switch to snap the starter clutch out of engagement.

The same setup can also be used for the FOD screen* starter mounting. This setup is usually utilised for helicopter and turbo-prop installations.

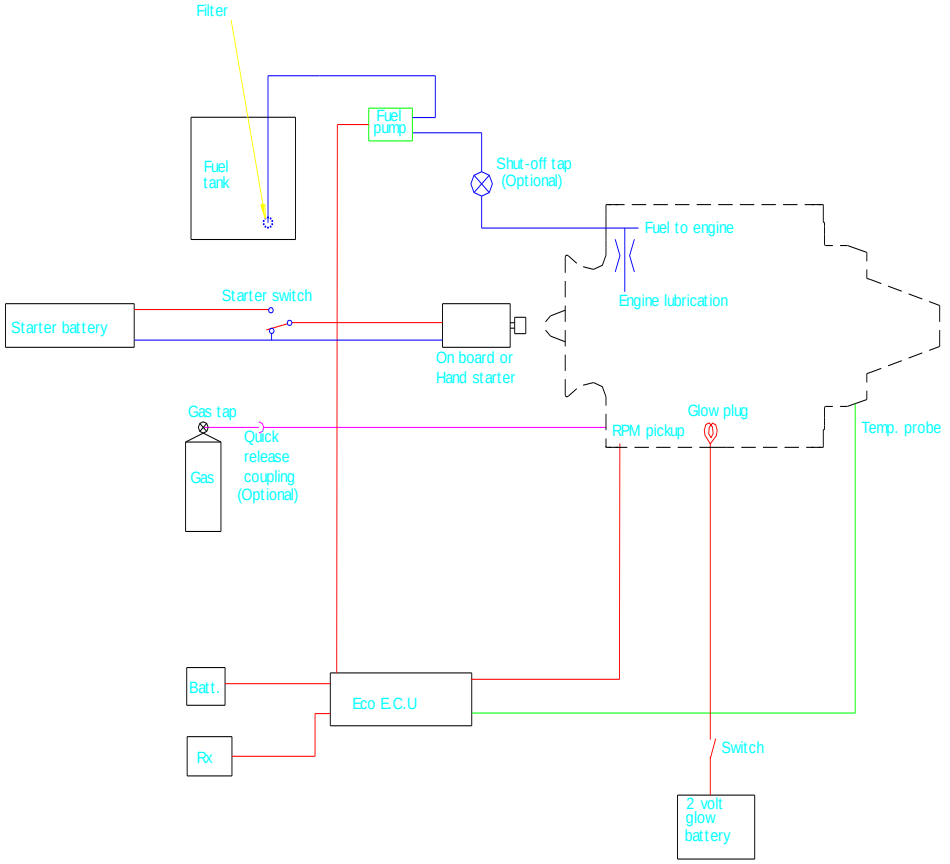
Note, picture shows Mk2 version, Mk3 version uses same setup and accessories.

NB. * Indicates accessories available from Wren Turbines Ltd.

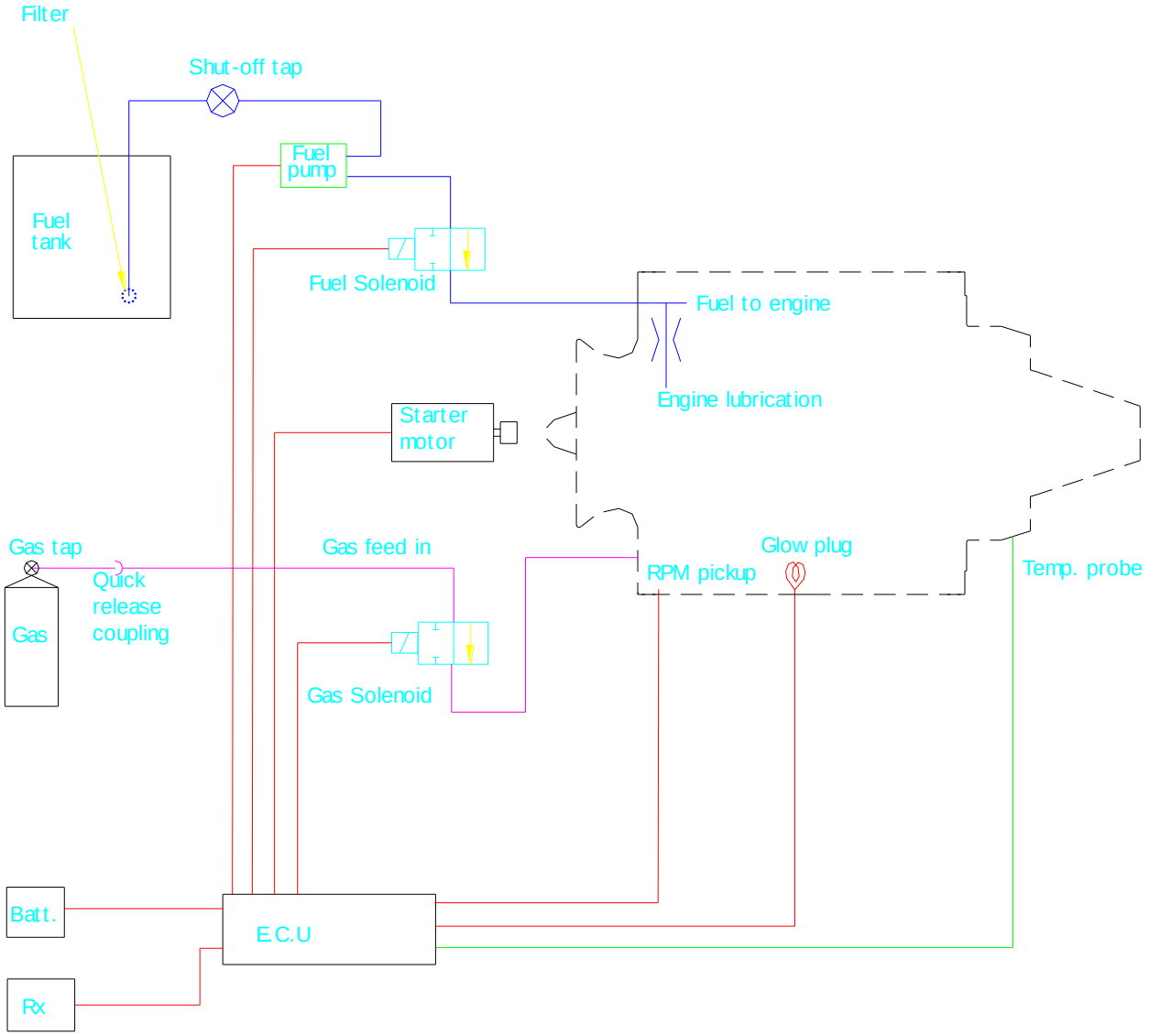
Manual start ecu schematic (hand starter).

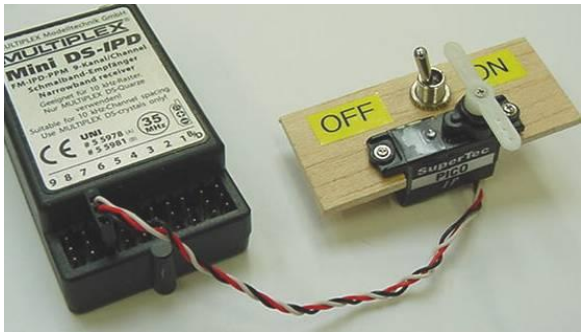


Manual start ecu (switched “pod” starter).



Autostart ecu schematic.





Engine Kill Switch.

It is good practice (and is a JMA requirement) to have an alternative means of shutting off the engine in emergencies. A simple method to achieve this is by putting a switch in the battery line to the ECU, operated by a mini servo mounted to a ply plate. The plate is drilled for a miniature toggle switch actuated by the servo arm – position it so it can only be reset by hand. The switch is wired in series with the positive (red) battery wire to the ECU (a cable is available if required). The servo should be connected to a channel which is operated by a switch on your transmitter so it can be operated quickly. The servo travel should be adjusted to ensure it is not stalled at either position.

Running your engine.

Before thinking of running the engine please re-read the safety section at the beginning of this manual

If you wish to verify your engine is working as it should and to perform some practice starting and running, then a simple baseboard with a pair of timber battens securely fastened will suit the task. Set the distance of the battens to suit your choice of mount used – the Wren 2-part mount is strongly recommended here as it holds the engine gently but firmly and can be easily transplanted later into your model. Affix a means of attaching your "peripherals", ie ecu and readout. The fuel tank, starter gas cannister where you can get to the valve, pump, batteries, etc all need securing or tying back so nothing is allowed to roll about or more importantly – get sucked into the engine. Ensure nothing flammable (fuel or gas) is located in the plane of (ie, in line with) the turbine wheel as in the unlikely event of a blade failure these would be at risk, so better to play safe.

If you wish to perform thrust tests as well as general start and running practice, then your test stand can be made up as above but the engine mounted in the form of a separate carriage that can roll on small wheels or slides such as are used for drawers. Wheels should ideally run in some sort of track that prevents the carriage skewing in any wrong direction – drawer slides do this already. Thrust can then be easily measured using a standard kitchen scales reading up to 22Lbs (10kg) mounted at the inlet end of the baseboard, and depressed by the carriage. Make a provision for limiting the maximum travel and a backstop to allow you to press against the compressor nut with your starter one handed (hand starters only), for starting, without the carriage rolling away. You will need to mount your peripherals either on the moving carriage or on a back panel attached to your baseboard and pipe-work/wiring extended as required.

Rpm and temperature are sensed using the ECU (Engine Control Unit). The FADEC "ECO" and "Autostart" have been tested with this engine and work well and are available from Wren.

The fuel tank (capacity around 1-1.5Ltr) is connected to the pump via a length of flexible piping. We do not recommend a filter in the suction line apart from a felt tank pick-up. The pump output should then go direct to the "tee" fitting in the fuel line of the engine, a shut-off valve may be

inserted in this line. The fuel feed to the engine will be from the other side of the "tee" and a lubrication take-off comes from the branch of the "Tee", which supplies a small amount of fuel to the bearings. Use clear piping for fuel pipes so you can see the fuel flowing, which will help your starts stay smooth.

The small Hausl ZP28028W fuel pump is suitable for the MW54 and is supplied in the kit package. The output is up to 3Bar @ 250ml/min. Higher capacity pumps will have to run slow to give a suitable idle of around 50ml/min and may make the engine unstable and have difficulty in getting smooth and controlled starts, so are not recommended.

A tank capacity of 1Ltr should be sufficient for a run of 6-8minutes. Oil should be added to the fuel, to a ratio of 3% oil to 100% fuel, that's 33:1, or 30cc of oil to 1Ltr of fuel. Use oil to grade TCW3, or alternatively turbine oil can be used. If you opt for turbine oil be careful not to breathe the fumes as they can be harmful to health.

A propane/butane or pure propane bottle is connected to the gas connection via a regulator or suitable tap connection – gas blowlamps have the valve and connection all in one and are useful for conversion! A cheaper option is to purchase a ready-to-fit gas tap, available from Wren Turbines, which simply screws onto the gas cannister. Note the gas supply must not be liquid gas so **do not** use a cannister with a dip or flop tube.

Check that the starter motor turns the engine with NO rubbing and that all your batteries are freshly charged. Fuel up your tank and we are ready to go!

Starting the engine.

OK, so you've assembled and balanced the engine perfectly, mounted it on a stand, got all your running gear set up and got a helper - you're now at the point where you turn from spectator to fully fledged turbine operator!! You should be out in the open and definitely not tucked into your garage hoping no-one will hear – they will, and you will suffocate with the fumes! Make sure you are wearing your ear defenders and have your fire extinguisher close to hand. Re-read the safety Instructions at the front just to be sure you haven't forgotten anything. Have a colleague on hand to operate fire extinguisher if needed. Do not make these first runs in public – you've a lot to concentrate on as it is.

Ready? First, check any set-up information supplied with your ECU. Connect your ecu readout. Place your transmitter where it can be easily reached (not on the ground). Set your trim to "stop", turn on transmitter then the receiver and watch for the display coming on. Verify ECU is at "stop". Check the temperature at which the fuel ramp starts (usually 100'C)– you will need to get to at least this on the gas, to start. You can now raise your trim to the "start" or "ready" position – verify this on the display and there is also a green led which lights on the end of the ecu. Turn on your glow-plug supply and spin the engine up gently to a few thousand rpm with the starter motor and let the rotor spin down whilst opening up the gas. **The rest happens quickly so be ready!**

Starting. You will hear a "plop" as the gas lights back into the engine and this is the signal to open the gas a little more. Blip your starter motor or starter wand to spin the engine up gently – not too fast or you will blow out the gas – say about 8-10,000rpm. You should see the ECU showing a temperature rise and once over 100'C it will then start to ramp up the fuel pump and fuel should then start flowing to the engine. Keep blipping until you hear the engine note change to indicate the fuel has arrived at the engine and it will start to accelerate quickly. Switch the starter full on at this time **and keep it on** while it to accelerates up **past 30,000rpm** - it is not able to run on it's own below this speed. The engine should now be accelerating nicely and once over 32,000rpm or so you can remove or switch off the starter and the gas and glow-plug may now be turned off. The ECU should continue to ramp the engine up towards the idle where it will settle at the point set – normally around 45,000rpm and that is it!

The engine runs at its coolest at about 80,000rpm and this is a good "soak" speed to let the engine settle down, where the temp is often around 480-520'C depending on the air temperature.

Your first time?

A common mistake for first time turbine operators is to spin the engine too quickly whilst on the gas, which will cool the engine below 100'C and the pump will then stop. Simply increase the gas if required and remember to only blip the starter during this phase. Watch also to confirm fuel travelling along the lubrication line.

The 2nd common mistake is to remove the starter too early, as the engine makes a noise like a jet engine a long time before it is capable of running by itself. If you have a hand starter you can feel when the engine is beginning to overrun the starter as the fit on the cone becomes "looser" and tends to wander slightly. With on-board starters the clutch pressure will lower as the engine picks up. The engine will be able to overrun the starter motor where the clutch will let go and make a horrible buzzing noise. Listen out for this and turn it off just before this point if you want your starter

motor bearings to last! If the clutch is even very slightly out of line it will drop out before the engine reaches self sustain and it will not start, or will have a hot start. Make sure therefore the starter clutch is perfectly aligned with the compressor spinner nut.
With practice a start need take no more than 10-15 seconds.

Noises?

All jet engines make a lot of noise – especially at full throttle, a deafening fantastic roar defined as "whoosh" by turbine enthusiasts – hence the ear defenders!
However, any unusual noises should be investigated immediately by shutting the engine down and close checking for rubbing – particularly the turbine in the first couple of runs and around the compressor/intake cone. A few sparks are normal as the engine settles down, but be sure they are not regular, caused by rubbing on the turbine. If the engine runs noisy, shut down and carefully feel the case as it runs down. If you feel vibration the rotor is out of balance. If the engine makes a high pitch whistle whilst running, carefully touch the outer case with the metal part of a screwdriver and feel the shank with your fingers. Again, if you feel a vibration the rotor is out of balance. Any penetrating noise that appears greater at the front of the engine is likely to be a compressor rub. Stop the engine and check immediately, this fault never clears, as the inlet cone picks up on the compressor and rubs harder, causing greater heat and more noise. Most noises are due to poor balance so be extra careful with this operation.

The engine is highly responsive and unlike early model turbines has an almost instant increase in speed and very little throttle lag. This will aid flying and make those overshoots easier! Do not exceed 160,000rpm.

Thrust.

When satisfied that there are no problems you can continue practising your starting and complete some thrust tests, and enjoy your handywork!!. Due to variations inherent in the casting process which manifest themselves in fractional differences in turbine and NGV profiles, kit engines can vary in thrust output from 5.5Kg to 6Kg (12lbs to 13lbs) for Mk2 engines and 6.2kg to 6.7kg (13.5-15lbs) for Mk3 engines.

Problems Checklist.

Use the following checklist to isolate and cure most problems:

Rotor rubs on intake	Intake not centred correctly – remove rotor, case, ngv and re-centre by moving case front. Check and confirm intake is not out of round. Rotor too far forward – rotor should have min of 0.1mm movement when pushed forward from turbine end – if less then fit intake shim (available free from Wren).
No reading on ECU display unit.	RX not switched on or RX battery discharged. Display not connected properly. Display malfunction. ECU problem.
Transmitter stick down/trim up reads "StickLo"	Radio set-up not completed correctly.
Temp" reading incorrect or missing	Thermocouple not connected to ECU. ECU problem Thermocouple failure
Temp' reading shows lower or minus figure when heated.	Thermocouple plug inserted wrong way round.
No rpm indicated when engine is spun.	Rpm sensor plug inserted incorrectly. Rpm sensor lead broken/chafed. Rpm sensor malfunction (return to dealer) ECU problem.
Gas will not ignite.	Gas bottle empty/low/ very cold. (Check gas flow by sound/smell) No glow at plug - plug blown (replace plug), plug supply not earthing (use earth lead fitted), glow battery flat (charge), glow element not exposed (tease out with pin), too high rotor speed (spin slower).
No or little temp' rise on gas lit.	Insufficient gas supply (increase flow/renew can) Too high rotor speed (spin slower) Temp' probe not inserted into exhaust cone, (insert 3-4mm)

	ECU problem.
Fuel pump not running.	Pump battery not charged (recharge). Pump or battery not connected (connect). ECU display not showing “Ready” – see “Starting the engine” Pump jammed with foreign object - connect briefly direct to battery to check operation. “Kill Switch” is in “OFF” position – switch to “On”. ECU problem.
Pump runs but no fuel delivered.	Fuel not reaching tank pick-up – blocked clunk, clunk jammed against roof of tank, feed pipe folded, air in fuel line, low fuel level. Fuel tap in “shut” position – “open”, Pump fault (return to dealer).
No or little rpm increase as fuel Ignites.	Insufficient revs on starter motor Starter battery low – recharge. Fuel tap only partially open – open fully. Pump battery low – recharge. Air in fuel line – air will disappear after several seconds. Tank feed problem – see above.
Excessive flaming.	Trim down/shut off fuel & gas immediately. Residual fuel in engine – spin engine “dry” for 10 seconds to clear. There was air in fuel system – restart. Insufficient revs on starter – recharge starter battery. Starter removed too soon – hold on until 32,000rpm minimum. Starter motor burnt out/inoperative – replace. ECU settings changed from defaults – return to defaults. Engine malfunction – investigate and repair – likely fuel ring problem.
Engine overshoots at idle.	Normal problem until ECU settles down. Starting technique too slow – practice. Air in fuel line causes late but rapid startup - ECU will correct itself and settle down.
Engine slows or is stopped during start.	“Overtemp’” is detected by ECU and shutdown. Temp’ has run over 800’C due to long hot start, low start battery, air in fuel line. Cool off and restart.

	Wild rpm reading – interference to rpm pickup by electromagnetic device sited too close, find and move.
Engine slows or stops during acceleration	Air in fuel line – check tank system for air-leaks/fuel flow problem. Blocked intake filter screen (if fitted) – unblock. Check TX setup – stick may not have been fully positioned on setup.
Engine slows in flight.	ECU battery discharged – recharge. Tank vent blocked preventing fuel being supplied – unblock. Clunk filter or fuel pipe blocked – unblock.
Engine stops in flight.	Low fuel, refuel. Air in fuel system – check tank system for leaks or blockages. Bad connection at pump, pump battery or ECU – check and solve. Rpm or temp' sensor faulty or bad connections – check and solve. "Kill switch" operation insecure – replace. RX interference causing ECU shutdown – find interference source and solve.
Excessive/unusual noise or vibration.	Engine out of balance due to poor balance or foreign object ingestion – investigate and replace damaged parts.

Maintenance.

As the engine has few consumable parts as such, beyond the bearings. We would not recommend taking it apart unless you need to do a visual check on bearing wear (perhaps prompted by noises), which only involves the rotor assembly. Bearing wear is expected to be minimal and is likely to be at its highest whenever the engine is reassembled and first run as the bearings have to settle back in onto their seating. For this reason it is advised to not do this unless any unusual noises are noted in which case immediate investigation is required. Do however check the various screws and fittings for tightness and note any apparent leaks. The O-ring seal at the front of the engine sometimes leaks a tiny bit in the area of the case seam, this is not usually a problem and can be sealed with a wipe of silicon sealer.

If there are any fuel leaks, then these must be investigated immediately, and rectified. Do not fly with a known fuel leak – if a fuel pipe were to come off under pressure neat fuel could be sprayed into the engine intake and could cause sudden over-speed of the engine with highly dangerous consequences. Leaks at pipe connections are often cured by trimming the last 4mm of tube and re-fitting into the quick-release fitting. Check the condition of your gas line regularly as this is connected to the hot part of the combustion chamber. Every time you rev the engine it pushes hot gases down the feed line through the quick release connection. In time the tube gripper loosens off and the fitting must be replaced if it is possible to easily pull the tube out. It is good practice to always trim the end of any tube which is removed from the connector and refitted, as a groove is left from the gripper which impairs sealing if reused too often.

On rare occasions an engine has been known pick up a stone from the runway and ingest it, causing a dent on a compressor blade. If this has happened do not run the engine hoping it will blow out through the turbine as it can cause much damage to turbine blades and ngv if trapped between ngv and turbine. The engine can be dismounted and shook with the compressor end downwards and often small stones etc will drop out. Otherwise it must be stripped and the engine checked thoroughly for foreign objects and cleared. A dented compressor **must** be replaced – straightening is not possible as a stress fracture will form at the bend point. Most dents on compressors with internal installations, are caused by debris left in the plane by the builder which the engine has "found" whilst doing a take-off or other manoeuvre which causes all the loose bits to fall to the back of the aircraft – unfortunately straight into the engine intake!

At Wren we had an engine brought in which refused to start. On investigation it was found to be full of sponge which had been used in the model to restrain batteries. This had become detached and sucked into the engine and shredded on its way in, completely blocking the diffuser and preventing air getting through the engine. It can and has happened and can happen to you if you are not extra careful!!

Please practice good housekeeping and eliminate damage from FOD – Foreign Object Damage.
Keep you and your MW54 healthy!

Above all, enjoy!

Parts and accessories for this engine are available from Wren Turbines Ltd. Please state your date of purchase to help us ensure the right part is supplied.

With thanks to all our past and present customers whose continued support have made this update of our kit worthwhile.

Mike Murphy
Wren Turbines Ltd
June 2004

Wren Turbines welcome feedback on this or other of their products, email on wren@parish.f9.co.uk or write to:
Wren Turbines Ltd, Unit 13, Century Business Centre, Manvers Way, Manvers, Rotherham, S63 5DA, England
Tel +44 (0) 1709 300290, Fax +(0) 1709 300291